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COMMENTARY

Use of a Rapid HIV Home Test to Screen Sexual Partners: A Commentary on Ventuneac, Carballo-Diéguez, Leu et al. 2009

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Abstract Previously, we estimated the HIV risk reduction that men who have sex with men could attain using a rapid HIV home test to screen sexual partners versus using condoms inconsistently. Here, we clarify the assumptions of our published formulas. Using models that more closely resemble our study population, our results show a difference from that presented in the original article in the magnitude of the relative advantage (i.e., lower risk of HIV infection) for HIV home test use versus inconsistent condom use. We present a general formula that can accommodate different types of partnerships in estimating risk of HIV infection.

Resumen Calculamos previamente la reducción en riesgo de transmisión de VIH que los hombres que tienen sexo con hombres podrían obtener usando un test rápido de VIH en la casa para selccionar parejas sexuales en vez de usar condones irregularmente. Aquí aclaramos las presuposiciones de las fórmulas publicadas. Usando modelos que se asemejan mejor a nuestra población clave, nuestros resultados demuestran una diferencia con los presentados en el artículo original en cuanto a la magnitud de la ventaja relativa (es decir, menor riesgo de infección con VIH) en caso del uso del test de VIH en la casa comparado con el uso irregular de condones. Presentamos una fórmula general que puede utilizarse con differentes tipos de parejas al calcular el riesgo de infección con VIH.

Keywords Probability of HIV transmission · Serosorting · Risk reduction for HIV · Gay men · Men who have sex with men

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In our article, “Use of a Rapid HIV Home Test to Screen Sexual Partners: An evaluation of Its Possible Use and Relative Risk” by Ventuneac, Carballo-Diéguez, Leu et al. published in AIDS Behavior [1], we provided formulas for calculating the probability of HIV transmission to facilitate a comparison of the public health risks and benefits of use of a rapid HIV home test to screen sexual partners among men who have sex with men (MSM). The formulas express the transmission probability as a function of an assumed number of partners per year and number of occasions of anal intercourse per partner per year, among other parameters, and build on the model used by Pinkerton and Abramson [2]. The two key parameters—m, the number of distinct partners per year, and n, the number of anal intercourse occasions per partner per year—require careful attention to assumptions related to partnerships types when they are estimated from samples of respondents asked about their sex behavior over a preceding period of less than 1 year. Indeed, the reported values of m and n from our own sample of men asked about their behavior for the preceding 2 months may not accurately reflect the actual behavior of our study population because the assumptions we tacitly used when estimating m and n were mutually inconsistent. The purpose of this commentary is to clarify these assumptions for the correct use of the published formulas and to present an even more general formula that can accommodate different types of partner relationships.

The expression we gave for the probability of HIV transmission if home test (HT) screening is used to screen partners is

$$P_{\mathrm{HT}} = 1 - \{(1-\pi) + \pi[\delta(1-\alpha)^n + (1-\delta) \{1 - \beta(1-\mu_{\mathrm{HT}})\}^n]\}^m$$

whereas, if HT is not used to screen partners, the probability of HIV transmission is

$$P_c = 1 - \{(1-\pi) + \pi[\delta\{1-\alpha(1-\mu_c)\}^n + (1-\delta) \quad \{1-\beta(1-\mu_c)\}^n]\}^m$$

In the above formulas, π is the probability that a sexual partner is HIV infected; δ is the conditional probability that a sexual partner is in the acute infection stage given that the partner is infected; α is the probability of infection per contact (anal sex occasion) during the primary/acute infection; β is the probability of infection during the chronic asymptomatic stage; μ_{HT} is the condom use effectiveness if HT is used (defined as the probability that an individual is protected by condom use with a positive partner in the non-acute stage, per contact after HT use, assuming that HT use is consistent with all partners); μ_{c} is the condom use effectiveness if HT is not used; and, as stated above, m is the number of partners per year and n is the number of occasions per partner per year.

In our discussion the quantity n was assumed to be the same for all partners and chosen at a value intended to represent a typical characteristic of the study population. To determine m and n, we used data from the Frontiers in prevention (FIP) study [3, 4], conducted in New York city with MSM who reported using condoms inconsistently or not at all. Among MSM who reported being HIV-negative, the median number of partners per respondent in the 2 months preceding their interview was seven and the corresponding median total number of anal intercourse occasions per respondent was ten. From these observations we annualized the observed median number of partners, setting $m = 7 \times 6 = 42$. We also annualized the number of occasions per partner per month, 10/7 = 1.43, setting $n = 1.43 \times 12 = 17$. Though the annualization of both quantities might seem reasonable on its face, the resulting scenario, $m = 42$, $n = 17$, while certainly representing a highly sexually active population, no doubt overestimated the actual risk behavior of the FIP study population.

To see why, consider two extreme cases. Let case 1 represent a "one-night stand" model, where each respondent would have different partners each and every month. Thus if men reported having seven partners in a 2 month period, the model assumption implies there would be a total of $m = 7 \times 6 = 42$ distinct partners per year. In that case, if men reported having anal intercourse on ten occasions in the 2 month period, the assumption implies that they would have only these ten occasions with those seven partners but no more with those same partners, so the number of occasions per distinct partner per year would be $n = 10/7 = 1.43$. Equivalently, one could reason that there would be $10 \times 6 = 60$ occasions in total for the year deriving from 42 partners, so that $n = 60/42 = 1.43$.

At the other extreme, let case 2 represent a "multiple long-term buddy" model with m stable partnerships for the entire year. With reports of seven partners for the 2 month reporting period, the model assumption now implies there would only ever be those seven distinct partners, i.e., $m = 7$. But then we must assume each of those partners will continue providing occasions over the entire year, so there will be (10/7) × 6 or $n = 60/7 = 8.57$ occasions per partner per year. Equivalently, one could reason directly that there would be 60 occasions in total for the year provided by the same seven partners, so $n = 60/7 = 8.57$.

Notice that in either model, we should have assumed only 60 total occasions per year rather than $42 \times 17 = 714$ total occasions per year, which represents a much riskier scenario. In general, actual populations could be expected to behave somewhere in between the one-night stand model and the multiple long-term buddy model. If one knows or is willing to assume the total number of occasions over the entire year for each partner, irrespective of how long the partnership lasts, a more general formula can be used to estimate the risk. Let n_i denote the number of occasions for partner $i = 1, \ldots, m$. Then

$$P_{\mathrm{HT}} = 1 - \prod_{i=1}^{m} \{(1-\pi) + \pi[\delta(1-\alpha)^{n_i} + (1-\delta)\{1-\beta(1-\mu_{\mathrm{HT}})\}^{n_i}]\}$$

if HT is used to screen partners, and

$$P_{\mathrm{c}} = 1 - \prod_{i=1}^{m} \{(1-\pi) + \pi[\delta\{1-\alpha(1-\mu_{\mathrm{c}})\}^{n_i} + (1-\delta)\{1-\beta(1-\mu_{\mathrm{c}})\}^{n_i}]\}$$

if HT is not used to screen partners. These expressions will lie in between the simpler expressions given above where, in general, one should determine the total number of occasions per respondent per year, say N, and then set $n = N/m$, where, m should be determined carefully according to partnership type.

Table 1 below compares the probability of HIV transmission under the three scenarios just presented. The results show a difference in the magnitude of the relative advantage (i.e., lower risk of HIV infection) under the HT condition versus inconsistent condom use between the

Table 1 Probability of becoming HIV infected using HT to screen versus inconsistent condom use

π (%)	γ_C	$\delta_{(2.5\%/4\pi)}$				$\delta_{(5.5\%/4\pi)}$				$\delta_{(7.6\%/4\pi)}$			
		P_{HT}	Case 0 $m = 42$; $n = 17$ P_C	Case 1 $m = 42$; $n = 1.43$ P_C	Case 2 $m = 7$; $n = 8.57$ P_C	P_{HT}	Case 0 $m = 42$; $n = 17$ P_C	Case 1 $m = 42$; $n = 1.43$ P_C	Case 2 $m = 7$; $n = 8.57$ P_C	P_{HT}	Case 0 $m = 42$; $n = 17$ P_C	Case 1 $m = 42$; $n = 1.43$ P_C	Case 2 $m = 7$; $n = 8.57$ P_C
8.4	0	Case 0: 0.103	0.180	0.018	0.017	Case 0: 0.192	0.256	0.028	0.026	Case 0: 0.249	0.304	0.035	0.032
	0.25	Case 1: 0.011	0.143	0.014	0.013	Case 1: 0.021	0.207	0.021	0.020	Case 1: 0.028	0.249	0.026	0.025
	0.50	Case 2: 0.010	0.103	0.010	0.009	Case 2: 0.019	0.152	0.015	0.014	Case 2: 0.026	0.185	0.018	0.018
	0.75		0.060	0.005	0.005		0.090	0.008	0.008		0.110	0.010	0.010
12.1	0	Case 0: 0.111	0.222	0.023	0.022	Case 0: 0.199	0.294	0.032	0.031	Case 0: 0.256	0.340	0.039	0.037
	0.25	Case 1: 0.011	0.177	0.017	0.017	Case 1: 0.022	0.238	0.025	0.024	Case 1: 0.029	0.278	0.030	0.028
	0.50	Case 2: 0.011	0.128	0.012	0.012	Case 2: 0.020	0.175	0.017	0.017	Case 2: 0.027	0.207	0.021	0.020
	0.75		0.074	0.007	0.007		0.103	0.009	0.009		0.123	0.011	0.011
14	0	Case 0: 0.115	0.242	0.025	0.024	Case 0: 0.203	0.312	0.034	0.033	Case 0: 0.260	0.357	0.041	0.039
	0.25	Case 1: 0.012	0.194	0.019	0.018	Case 1: 0.022	0.254	0.026	0.025	Case 1: 0.029	0.293	0.031	0.030
	0.50	Case 2: 0.011	0.140	0.013	0.013	Case 2: 0.021	0.187	0.018	0.018	Case 2: 0.027	0.218	0.022	0.021
	0.75		0.081	0.007	0.007		0.110	0.010	0.010		0.130	0.012	0.012
18	0	Case 0: 0.124	0.284	0.029	0.029	Case 0: 0.211	0.350	0.039	0.037	Case 0: 0.267	0.393	0.046	0.043
	0.25	Case 1: 0.013	0.228	0.023	0.022	Case 1: 0.023	0.286	0.030	0.029	Case 1: 0.030	0.323	0.035	0.034
	0.50	Case 2: 0.012	0.166	0.016	0.015	Case 2: 0.021	0.211	0.021	0.020	Case 2: 0.028	0.241	0.024	0.024
	0.75		0.096	0.009	0.009		0.125	0.012	0.011		0.145	0.014	0.013
20	0	Case 0: 0.128	0.304	0.032	0.031	Case 0: 0.215	0.368	0.041	0.040	Case 0: 0.271	0.410	0.048	0.046
	0.25	Case 1: 0.013	0.245	0.024	0.024	Case 1: 0.023	0.301	0.032	0.031	Case 1: 0.031	0.338	0.037	0.035
	0.50	Case 2: 0.012	0.178	0.017	0.017	Case 2: 0.022	0.223	0.022	0.022	Case 2: 0.028	0.253	0.026	0.025
	0.75		0.104	0.009	0.009		0.132	0.012	0.012		0.152	0.014	0.014

Note: π = HIV prevalence; δ = HIV incidence/4π [e.g., 2.5% $\div$ (4 $\times$ 8.4%)]; γ_C = condom use consistency; P_{HT} = probability of infection under the HT condition, the value of P_{HT} in the three case do not depend on the four rows corresponding to γ_C; P_C = probability of infection under various condom use consistency levels (HT is not used to screen partners) probabilities of becoming HIV infected originally presented (Case 0) and the two cases that more closely resemble the FIP study population (Cases 1 and 2). With lower prevalence (8.4%) and factoring in incidence of 2.5%, for example, the probability of infection was reported to be about 8% lower under the HT condition versus no condom use (0.103 vs. 0.180, respectively). Under the assumptions presented for the two cases, the probability of infection is only .7% lower under the HT condition versus no condom use (Case 1: 0.011 vs. 0.018, respectively; Case 2: 0.010 vs. 0.017, respectively). With HIV prevalence of 20% and incidence of 2.5% for the two cases, the probability of infection is 1.9% lower under the HT condition versus no condom use. The relative advantage of HT use as a strategy in reducing one's risk of becoming HIV infected as compared to inconsistent condom use depends heavily on the total number of occasions per respondent per year ($N = mn$), but only weakly on the particular values of m and n with fixed product. To a lesser extent, the relative advantage depends on the prevalence of HIV in the population, as reported previously, but less so on the incidence rate of HIV.

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